Life Prediction of Ceramic-and Metal-Matrix Composites

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In order to save weight and increase performance, new rocket systems will continue to make use of ceramic- and metal-matrix composites. Currently, MSFC is developing a design analysis tool to determine the useful life of rocket engine components made with ceramic-matrix and metal-matrix composites.

The technical objectives of the project have included the development of a new analysis technique that combines micromechanics, fracture mechanics, and statistical principles to model and predict the mechanical response and failure mechanisms of such composites. The proposed technique uses the coefficient of friction at the fiber-matrix interface as the interface parameter which, unlike the interfacial shear-stress parameter in the earlier models, can account for the effects of fiber diameter, fiber volume fraction, loading, transverse stress, and thermal effects. Thus, a single parameter can now be used to correlate data for different temperatures, as well as fiber volume fractions and loadings, which was not possible with earlier models.

For continuously reinforced composites, the failure mechanisms involve fiber-matrix debonding, fiber-bridged matrix cracking, and fiber failure in the wake of the matrix crack (fig. 85). The micromechanics, shear-lag, and continuum fracture mechanics models will be integrated with a statistical model to develop a general-purpose ceramic- and metal-matrix composite life-prediction analysis code (fig. 86).

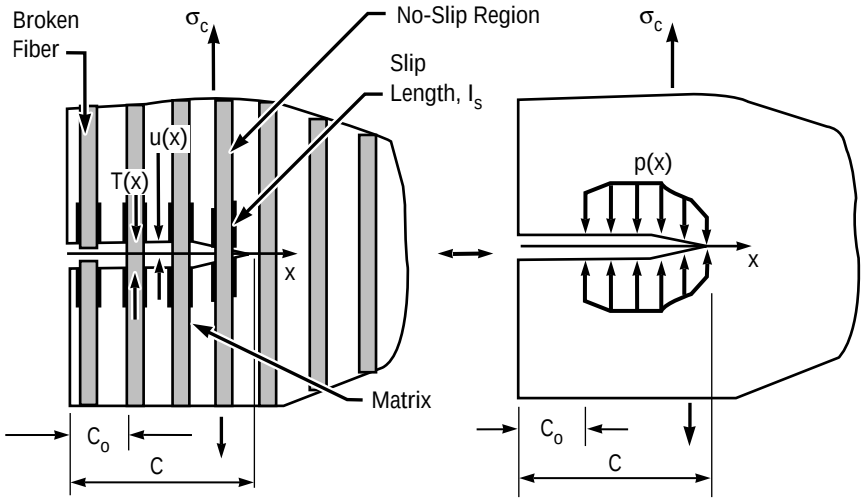

FIGURE 85.—Schematic representation of failure modes in ceramic- and metal-matrix composites with corresponding continuum idealization.

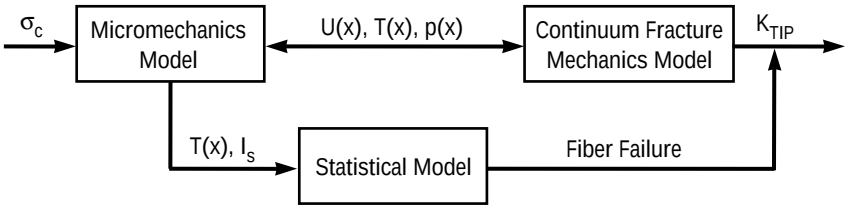

FIGURE 86.—Flow chart describing analytical techniques.

The successful completion of this effort will result in the development of a new, analytical tool called "CMLife." The tool will be used for fatigue life prediction of laminated and textile ceramic-matrix and metal-matrix composites, thereby fulfilling a critical need in the design of high-temperature components at NASA and in industry. A menu-driven, point-and-click user interface will enhance its appeal to engineers and designers, and it will be seamlessly integrated with a commercial finite element code for life prediction of ceramic- and metal-matrix composites.

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